



# ElectroSpark Deposition

studies for  
gas turbine engine component repair

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**Advanced Surfaces and Processes, Inc.**

***HCAT Program Review Meeting***  
**Grandover Resort & Conference Center**  
**Greensboro, NC 27407**

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# *Project Objective*

The goals of this project are to *demonstrate and validate* ElectroSpark Deposition (ESD) as technically feasible and commercially viable for a production-scale process, and to perform the tests necessary to transition ESD for use on gas turbine engine components.



# *Participants*

- ESTCP/HCAT
- PEWG
- Portland State University
- Edison Welding Institute
- Rowan Technology Group
- Pacific Northwest National Lab
- Air Force Research Lab
- General Electric Aircraft Engines
- Pratt & Whitney
- Tinker AFB

# *What is ESD?*

The ESD process is comprised of an electric arc through a consumable electrode energized by a series of capacitors. During the generation of the arc, small particles of the electrode material are melted and build-up occurs incrementally.

- Metallurgical bond
- Low heat input
- Rapid solidification
- No pre-ESD preparation
- No post-ESD processing
- Environmentally benign
- Portable
- Applicable for NLOS



# Demonstration Plan

- *Execution of a Joint Test Protocol*
- *Joint Test Report due 2006*
- *Component Specific*
- *Cost/Benefit Analysis performed by CTC*
- *Materials of Interest*
  - *IN718 on IN 718*
  - *410 SS on 410 SS*
  - *Ti-6Al-4V on Ti-6Al-4V*
  - *IN 718 on chrome plated IN 718*

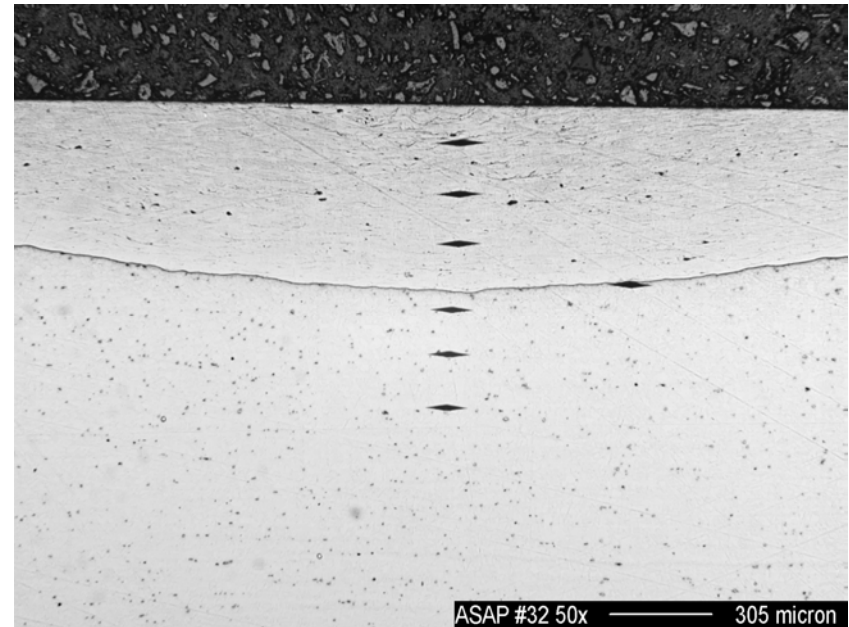
*EPP0202 Demo Plan Revision A.doc*

[www.hcat.org](http://www.hcat.org)

*HCAT Member WorkSpace → ESD → Test Plans → Demonstration Plan*  
<http://207.152.96.131/w2g/cgi/kmcgi.exe?O=DIR00000000GPM&V=0>

# Optimization

- *IN 718 on IN 718*
- *DOE Optimization*
- *Added UIT*
- *Metallurgical Evaluation*
  - ☐ *Deposition Rate*
  - ☐ *Microhardness*
  - ☐ *Porosity*
- *Two Parameter Sets Selected*



*Optimization Document Project # EPP 0202 (January 2005)*

[www.hcat.org](http://www.hcat.org)

<http://207.152.96.131/w2g/cgi/kmcgi.exe?O=DIR00000000GPM&V=0>

# *Joint Test Protocol*

- *Pin on Disk Wear*
- *Fatigue*
- *Residual Stress*
- *Corrosion*
- *Adhesion Bond*
- *Tensile*
- *Hamilton Sundstrand Wear*

*JTP Project # EPP 0202 (January 2005)*

[www.hcat.org](http://www.hcat.org)

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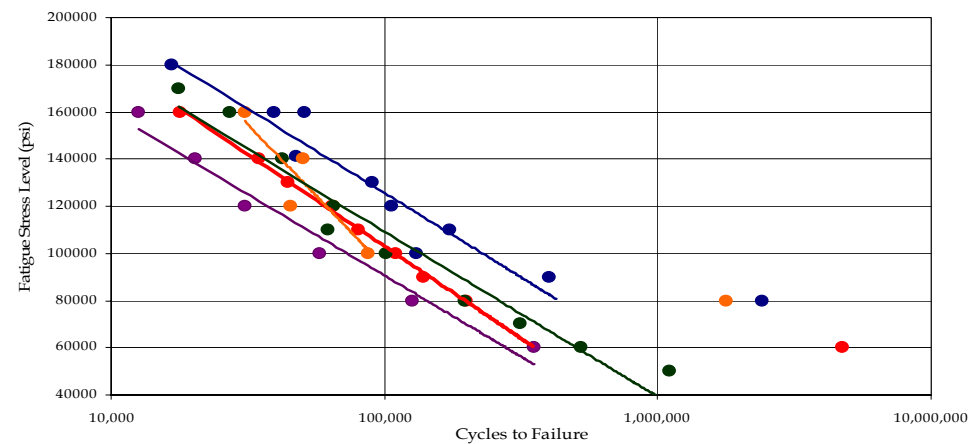


# Pin on Disk Wear

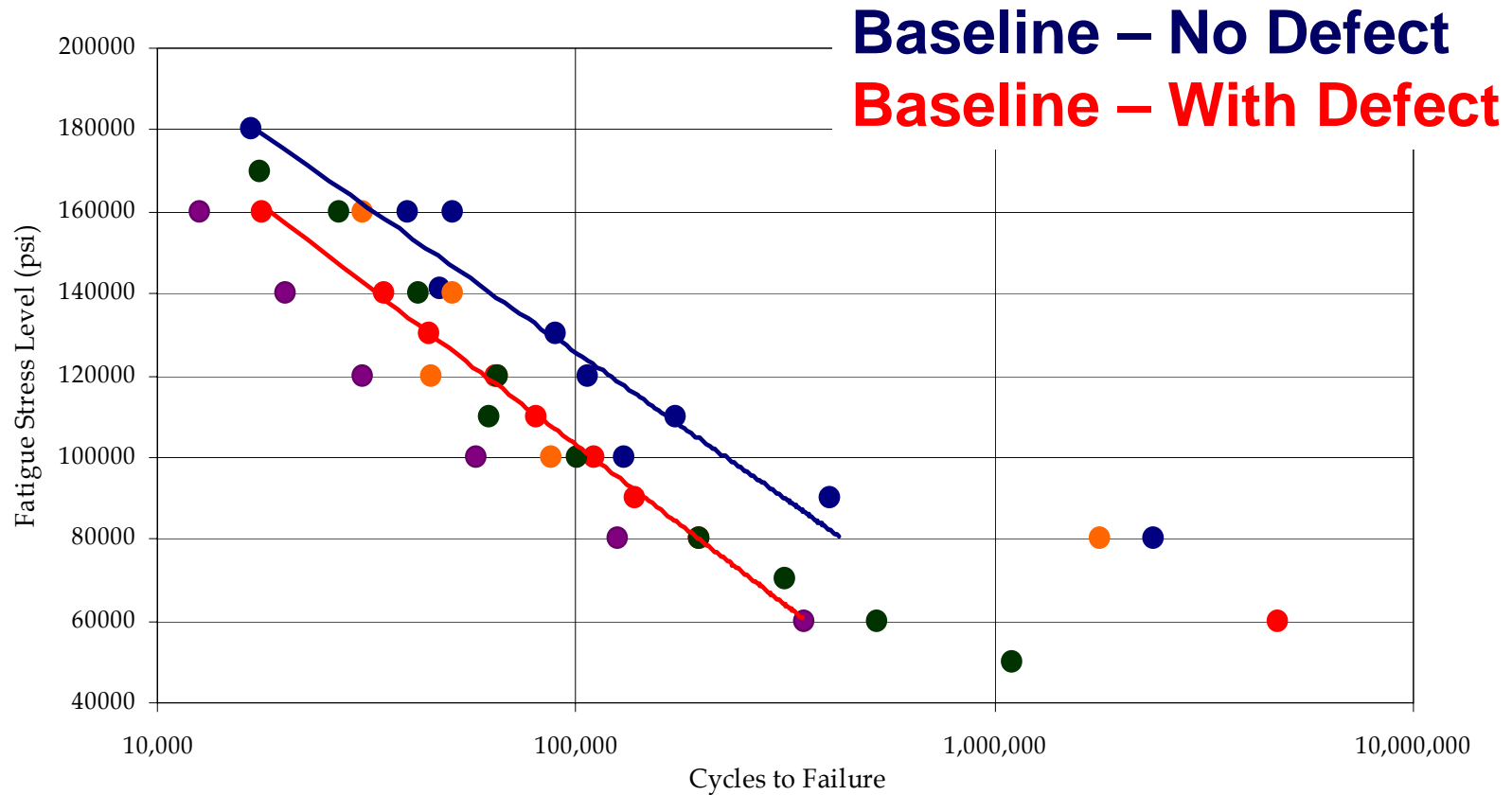


Specimen	Maximum Groove Depth	
	Base Metal	ESD
2-1	114	134
2-2	92	153
2-4	128	123
2-3 (long test)	218	194

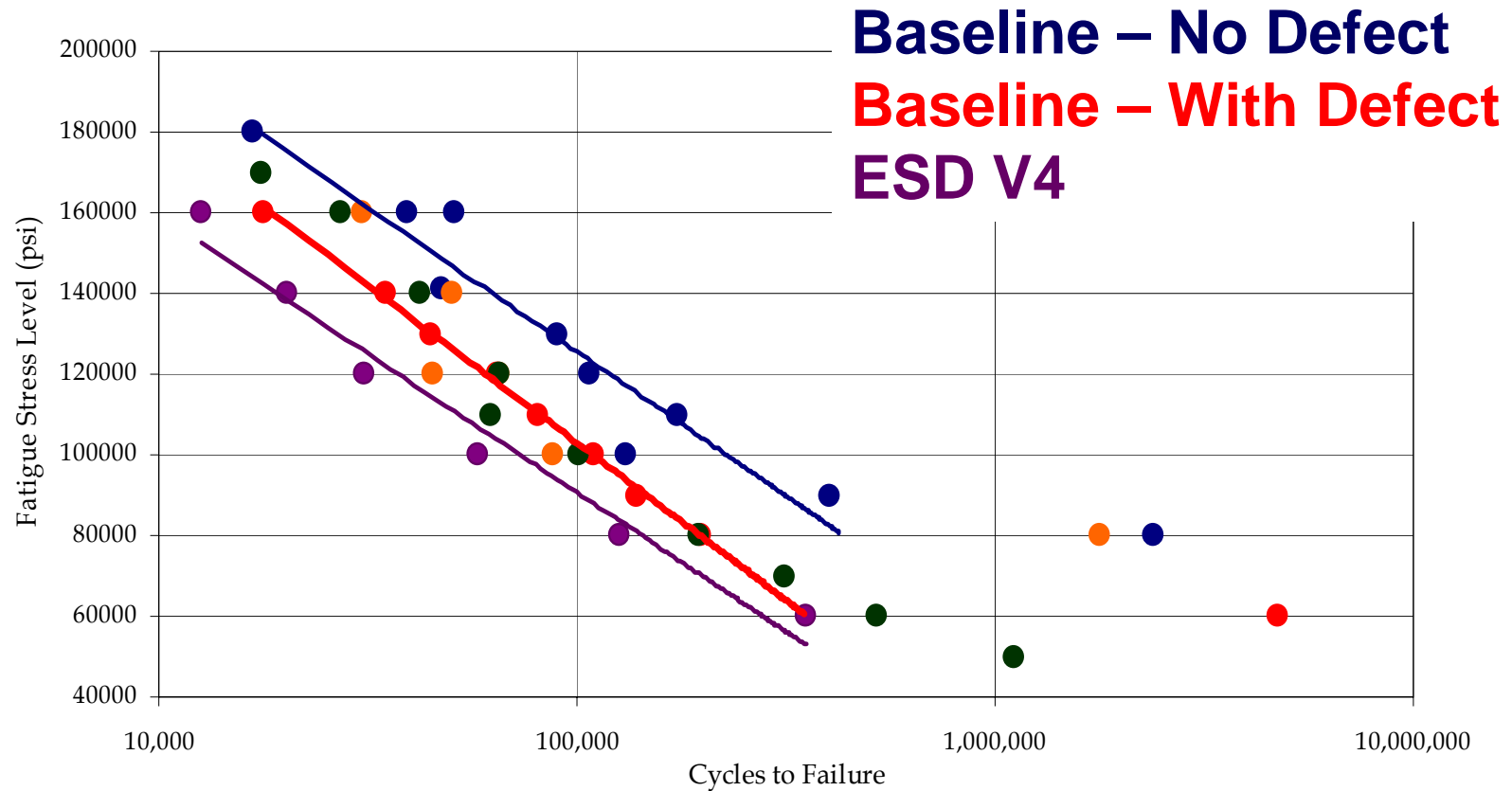
# Fatigue



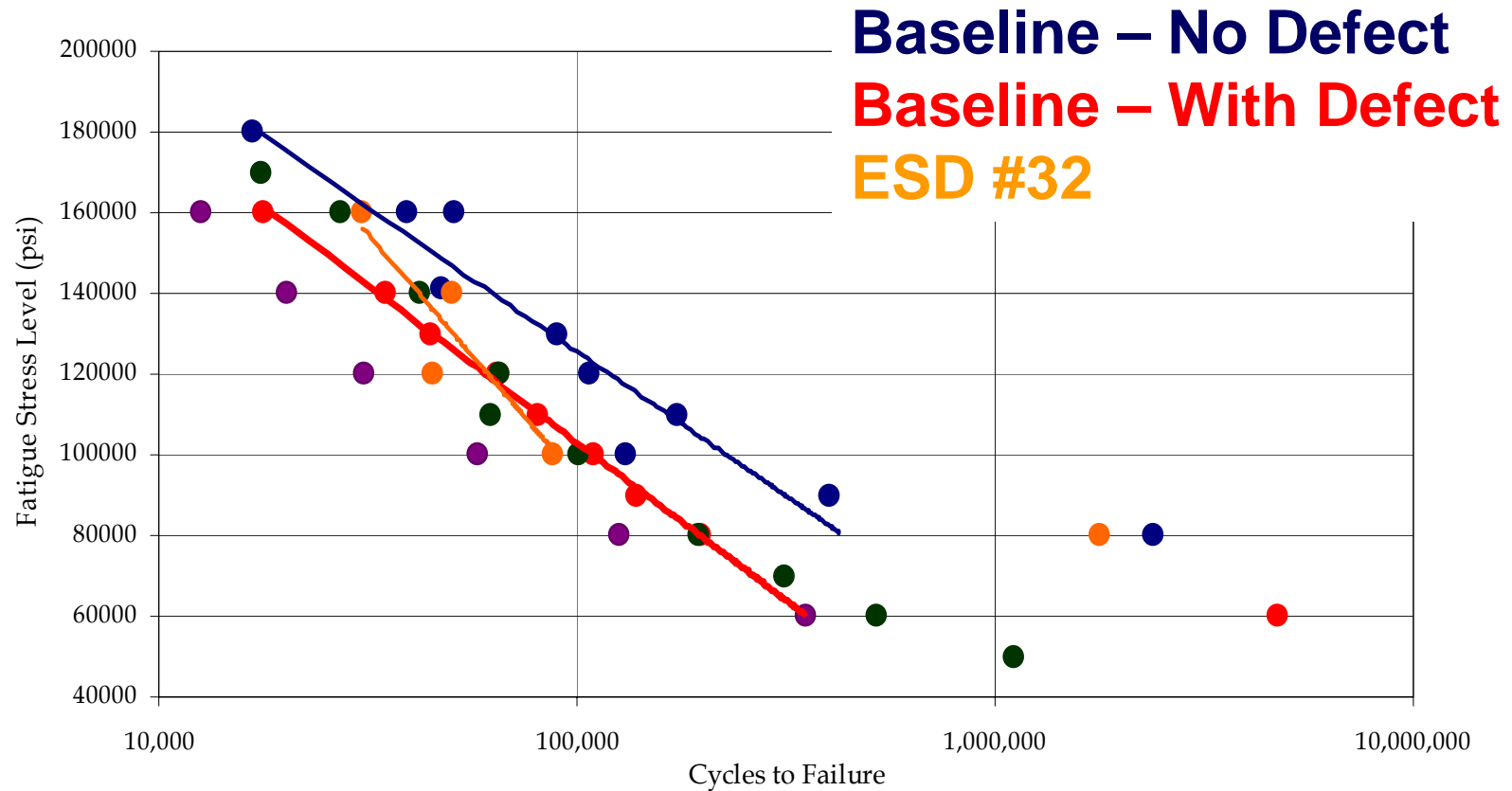
# Fatigue



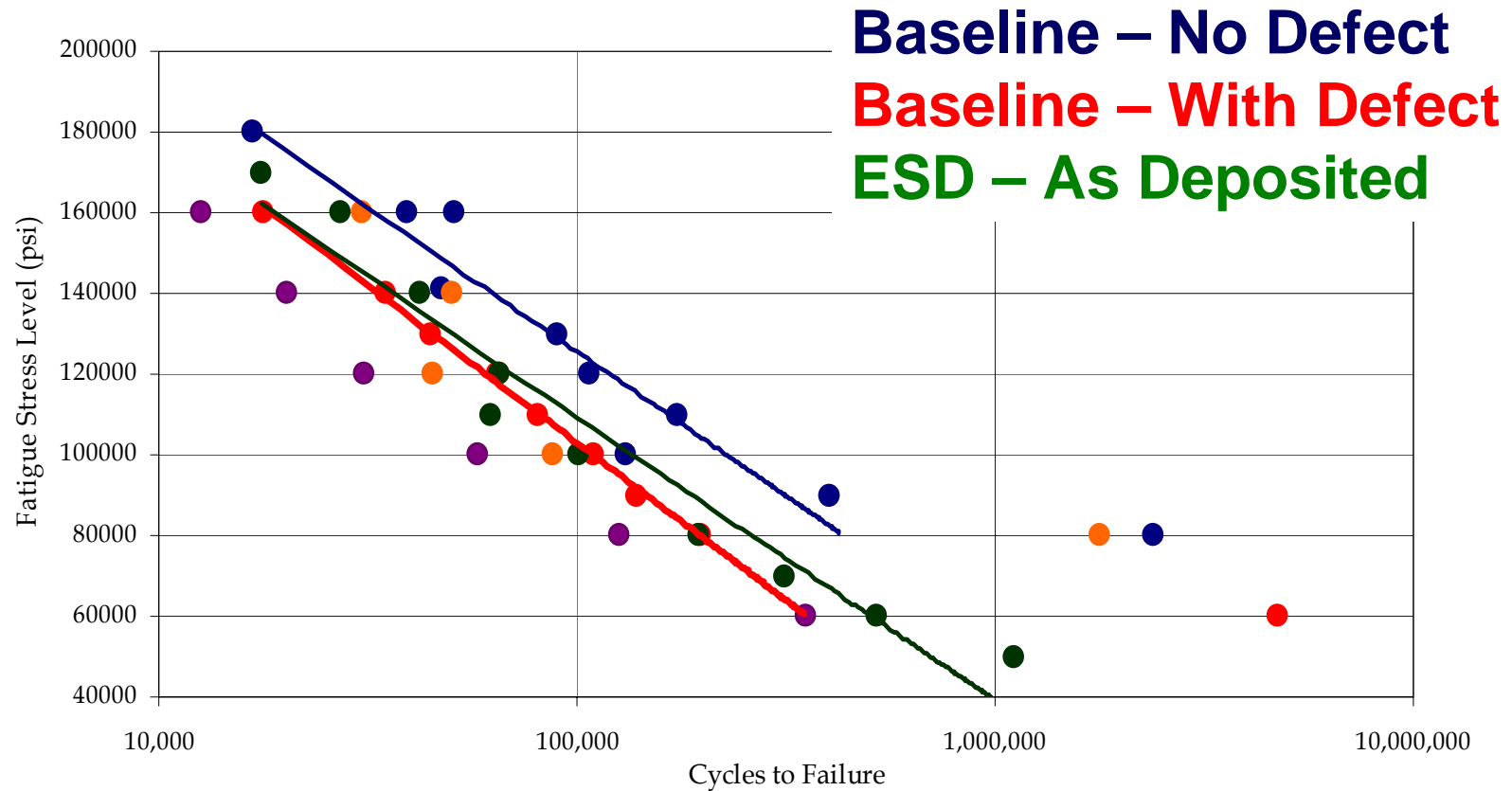
# Fatigue



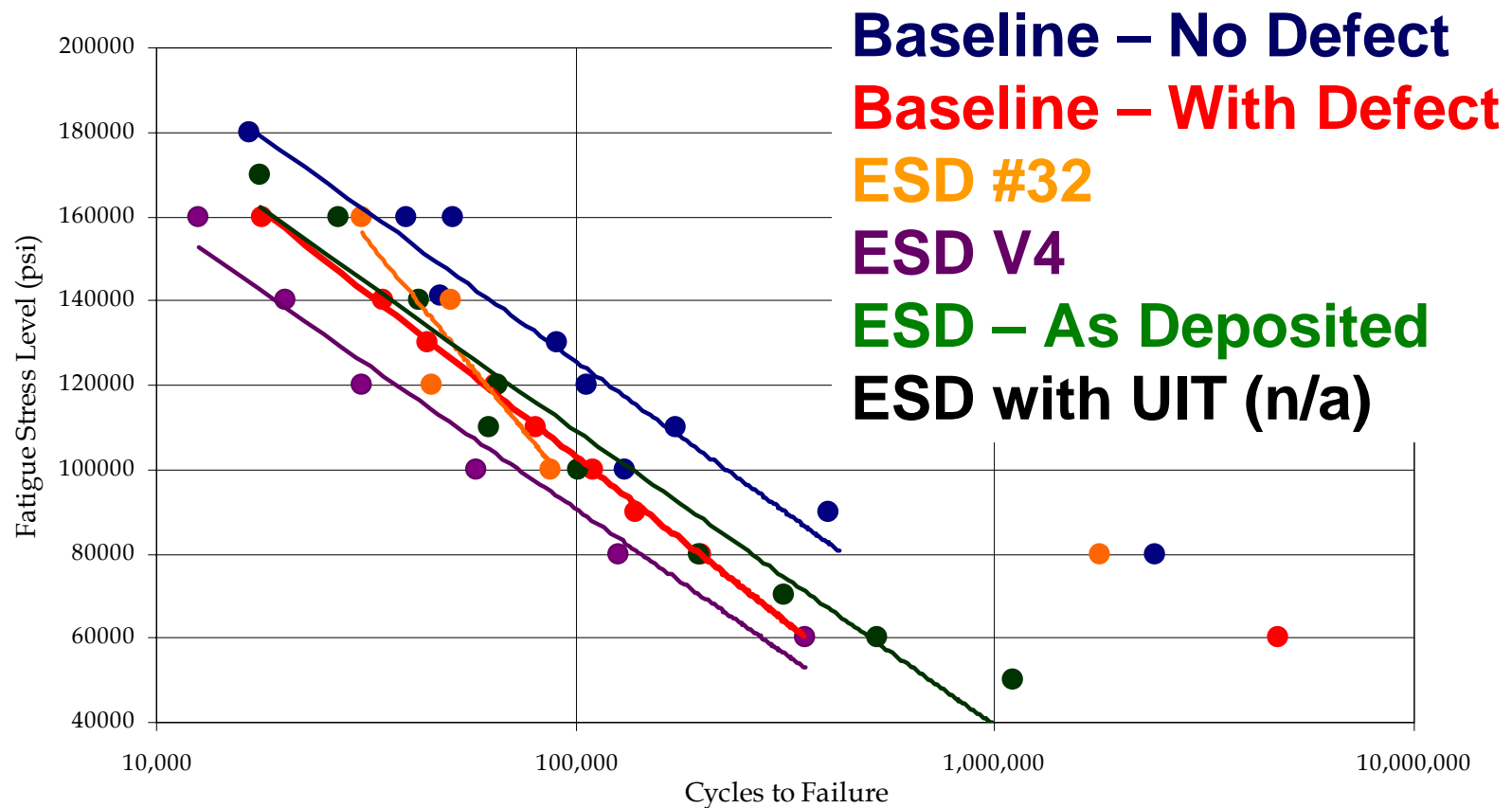
# Fatigue



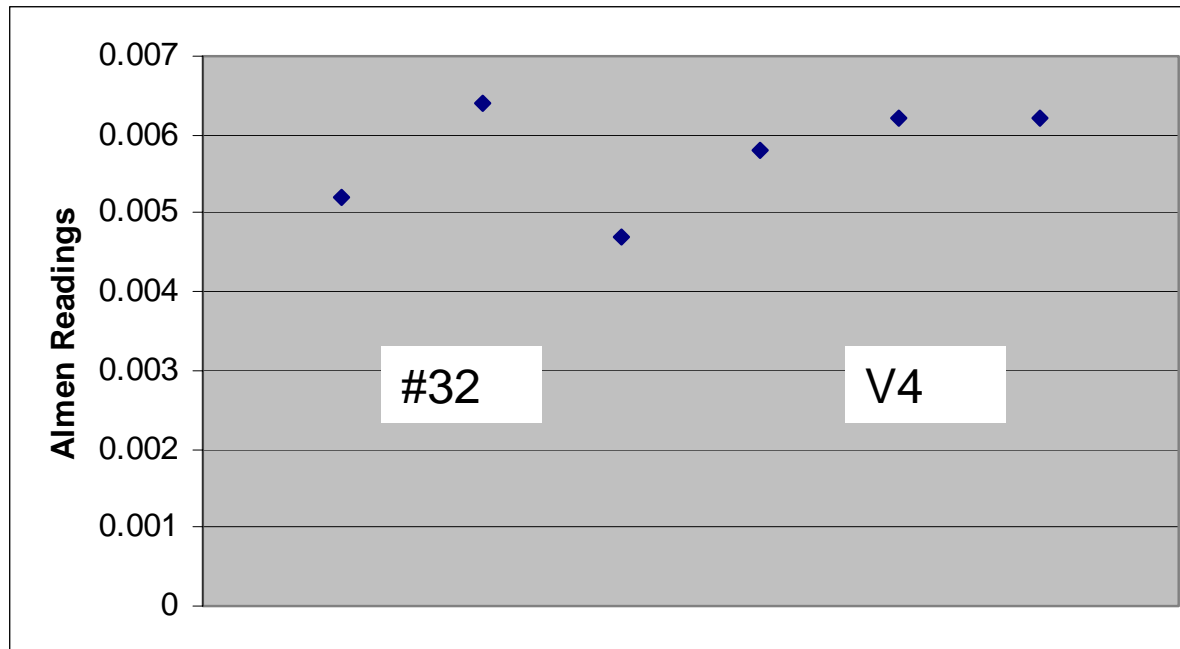
# Fatigue



# Fatigue



# Residual Stress



- *Tensile stresses with ESD*
- *Higher tensile stresses with increased energy*
- *Investigating stresses in ESD with UIT*



# Corrosion

- *Preliminary corrosion testing conducted following ASTM G-48, heated ferric chloride.*
- *Salt Fog ASTM B117 to be performed*

## Adhesion Bond

- *ASTM C 633 to be performed*

# *Tensile*

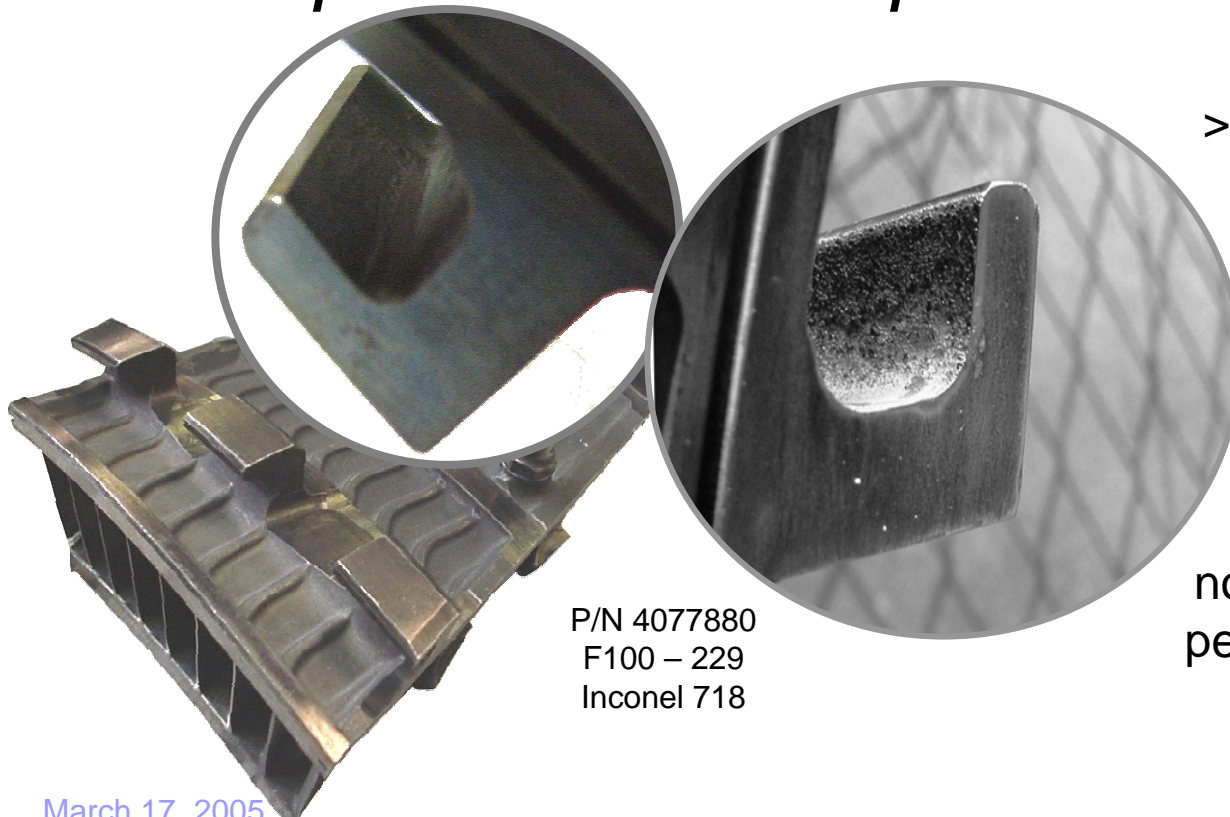
- *Tensile specimens being prepared by ASAP*
- *Some specimens will receive UIT*
- *Specimens sent for final surface finishing*
- *Tensile testing to be performed by PSU*

# *Hamilton Sundstrand Wear*

- *Specimens to be procured and prepared by ASAP*
- *Some specimens will receive UIT*
- *Specimens sent for final surface finishing*
- *Wear testing to be performed by Hamilton Sundstrand*

# 10-12 Stator Segment

- *ESD parameters under evaluation via JTP*
- *ESD process technique developed*



P/N 4077880  
F100 – 229  
Inconel 718

>0.005" deep wear in hook  
non-line-of-sight

Current repair:  
Cut off hook,  
weld on new,  
heat treat part

no repair if the part has met  
permissible heat treat cycles

# JTP for other materials

- *410 SS on 410 SS*
- *Ti-6Al-4V on Ti-6Al-4V*
- *IN 718 on chrome plated IN 718*

# Other ESTCP/HCAT/PEWG Activities

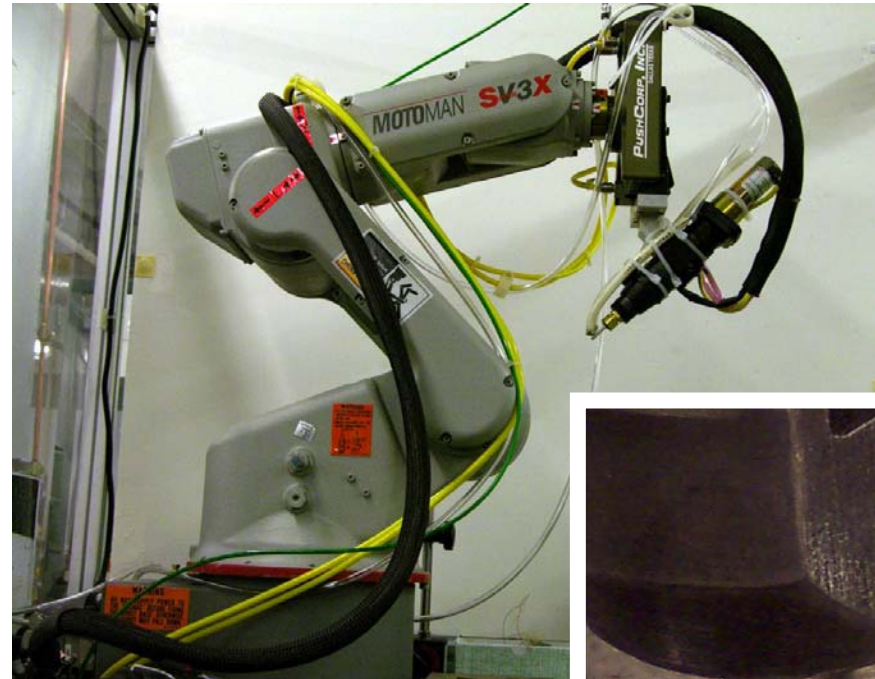
- *Chrome Plate repair*
- *Particle Emission testing*
- *ESD/Robotics/UIT*
- *#5 Bearing Housing*

# ESD, Robotics and UIT

## Improvement in ESD

### Automated with UIT vs. Manual

Production Deposition Rates	↑	11 X
Discontinuities	↓	0.8 X
Hardness	↑	1.3 X





# #5 Bearing Housing



P/N 712141

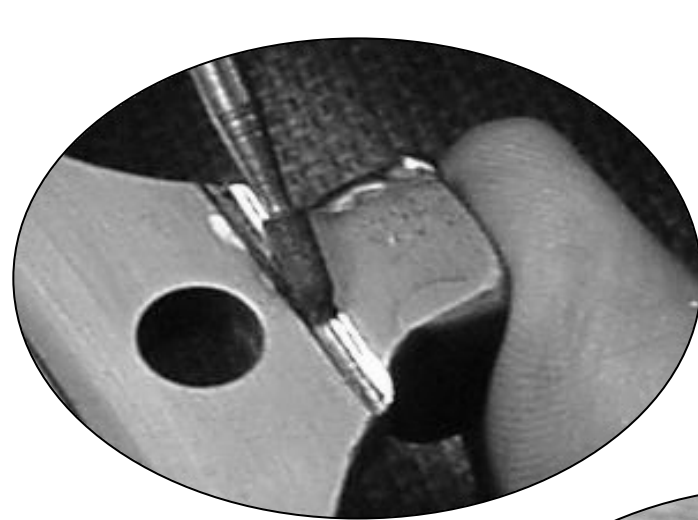
TF 33

AMS 5613

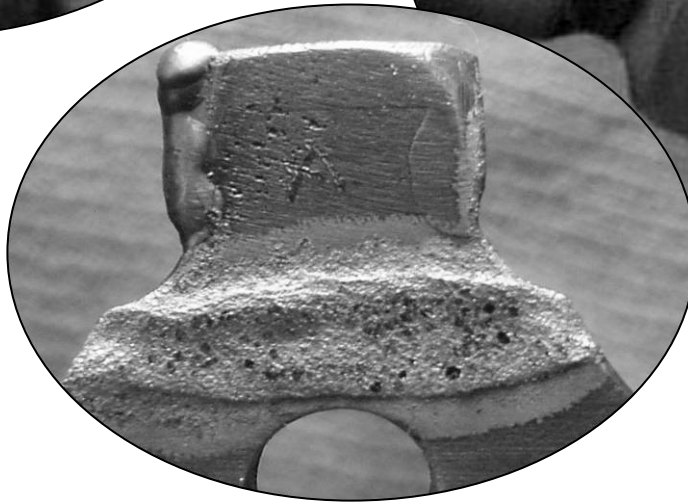
(410 stainless steel)



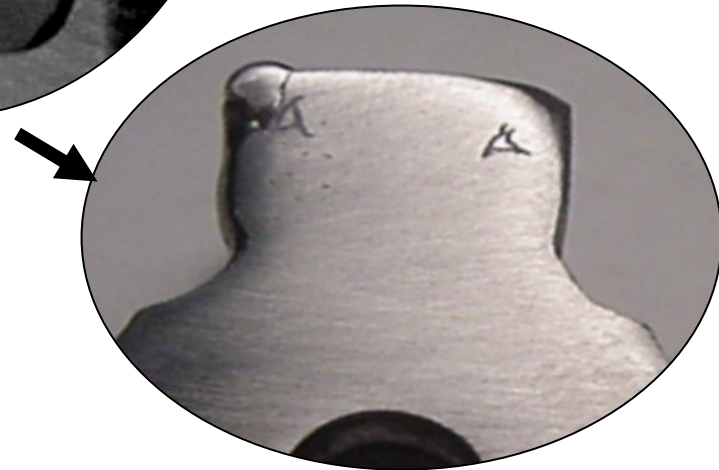
# #5 Bearing Housing



Excavate  
the defective area

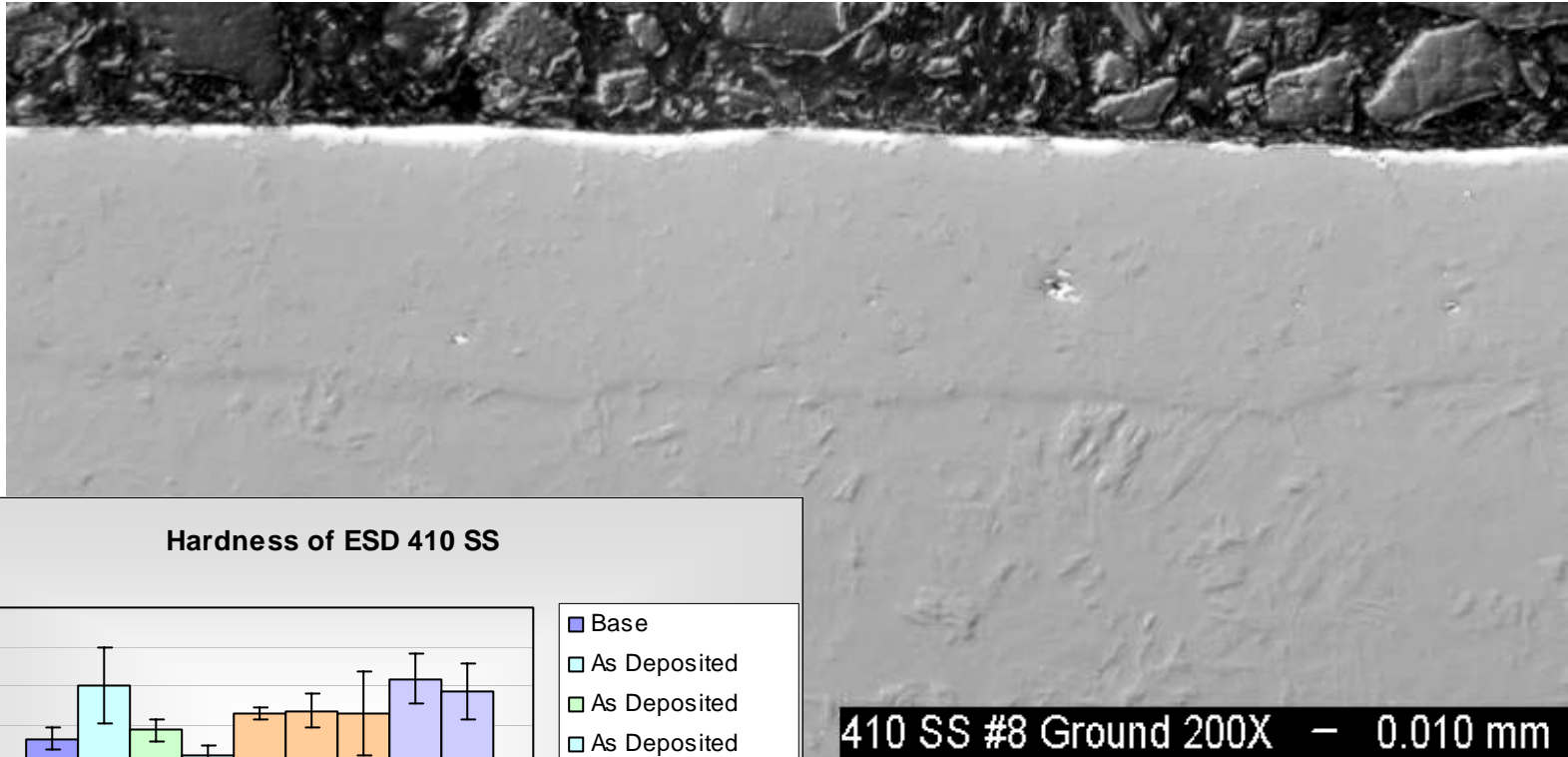


Fill with ESD

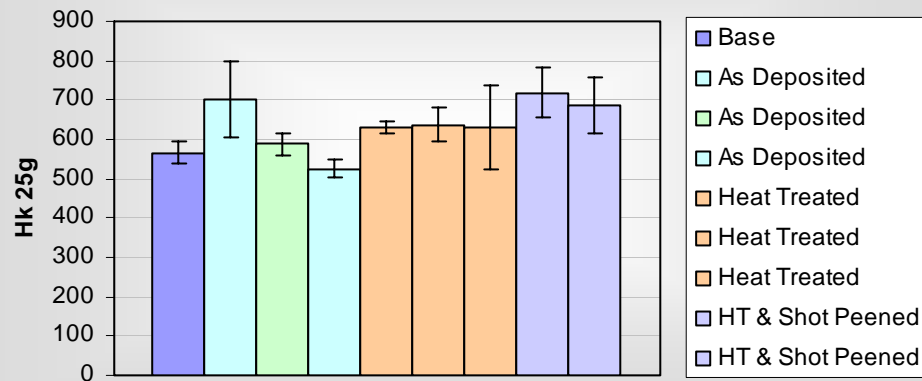


Blend to original surface

# #5 Bearing Housing



Hardness of ESD 410 SS



Welding Procedure Specification  
and hands on demonstration  
delivered at PEWG, Las Vegas,  
April 2004.



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